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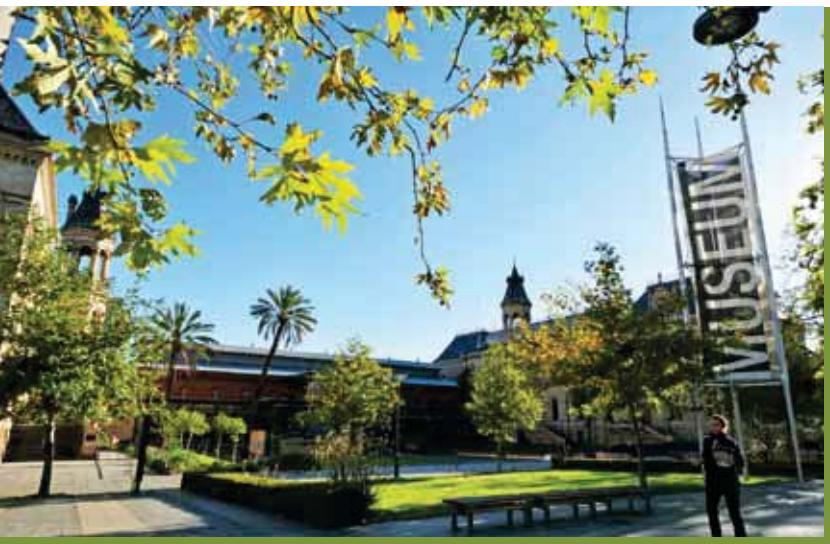

ABSTRACTS

Adapting to change: the multiple roles of modelling

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The benefits of sensitivity analysis in an interdisciplinary environment, a case study: the Ecomeristem model

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Abstract: The models developed by scientists are more and more complex. Indeed, these models are composed of a large number of sub-models than can interact with other models and sub-models. These processes and interactions define non linear and non derivable outputs. This is why we need to analyze the properties of such models if we want to qualitatively validate them, infer new knowledge or evaluate the impact of an event on the system. In this context, the use of sensitivity analysis seems fundamental and is a tool that allows having a better understanding of our models. This paper presents why and how we use sensitivity analysis on the Ecomeristem model. Ecomeristem is a whole-plant, deterministic, dynamic, radiation and temperature-driven crop model within the category of Functional Structural Plant Modeling. It includes also soil and plant water balance (to study, for instance, drought stress) modules. The main distinguishing mark of this model is its capability to simulate competition for assimilates (supply) among growing organs (demand). The plant is simulated as an average individual of a population forming a canopy. Plant organogenetic and morphogenetic processes are driven by incremental carbon assimilate source and sink depending on genotypic parameters and environmental conditions. This model has been developed in an interdisciplinary environment and is a result of collaborations and works between scientists involved in ecophysiology, genetics, computer science, and applied mathematics. For this study, we used the extended Fourier Amplitude Sensitivity Test (called `fast99` and comes from the `sensitivity` R package). This method allows the estimation of first order and total Sobol' indices for all the factors. One of the main advantage of this method is that if n is the sample size and p the number of factors, the number of simulations needed to produce the sensitivity indices is: $n \times p$. Using `fast99` we carried out a large number of sensitivity analysis. These results help us to build and improve the ecomeristem model. They help to have a better understanding of the biological processes we modeled and allow to note that they processes behave properly (*e.g* the variation of input parameters implies the variation of the observed output variable). Moreover, in a computer science point of view, by performing a large number of simulation, and consequently, a large number of simulation trajectory, the combination of input parameters values proposed by `fast99` allows to exhibit remaining bugs within the model. Due to the large number of interactions between the models, this work would be very hard to do so if scientists have to imagine these combinations of parameters.

For instance, we carried out a sensitivity analysis of shoot dry weight simulations to model plant parameters under drought. Plasto, defining the constitutive leaf appearance rate, showed the highest sensitivity indices, prior to other constitutive sink related and drought response parameters. However, Epsib, light conversion efficiency, showed sensitivity indices similar to Plasto (around 0.55) with even a slightly higher main effect. The impact of drought response parameters was generally low excepted powerFTSW (sensitivity of carbon assimilation to drought) showing sensitivity index of almost 0.2 and being thus the third most influent parameter.

Keywords: *Functional Structural Plant Models, Plant biology, Ecophysiology, Sensitivity Analysis, Modeling, Simulation*